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A PROGRESS REPORT ON HARVESTING AND HANDLING CONCORD GRAPES [1/]

By S. L. Hedden [2/], J. H. Levin [2/], and H. P. Gaston [3/]

In a normal year, Michigan produces about 50,000 tons of Concord grapes. The States of New York, Washington, Pennsylvania, Ohio, and Arkansas add sufficient tonnage to make the national production about 225,000 tons.

Grape harvesting and handling methods have changed but little in the last 25 years. During this period, labor and container costs have increased sharply and more attention is being focused on the quality of grapes for processing.

In 1958, a 5-year project was set up for the purpose of developing harvesting and handling methods and equipment that would (1) reduce labor requirements and costs, (2) help maintain on-the-vine quality, and (3) simplify management.

The purpose of this report is to make available information on what is being done and what has been achieved during the first 2 years.

WHAT HAS BEEN DONE

All available reports dealing with grape harvesting and handling were reviewed. It was found that very little experimental work had been done in this field.

1/ Based on work carried out jointly by the Harvesting and Farm Processing Research Branch, Agricultural Engineering Research Division, Agricultural Research Service, United States Department of Agriculture, and by the Departments of Horticulture and Agricultural Engineering, Michigan State University, East Lansing, Michigan.

2/ Agricultural engineers, Harvesting and Farm Processing Research Branch, Agricultural Engineering Research Division, Agricultural Research Service.

3/ Department of Horticulture, Michigan State University.

EXPERIMENTAL PROCEDURE

During the 1958 season conventional methods of harvesting and handling were studied and evaluated on the basis of labor requirements, cost and their effect on the quality of the product. The procedures of receiving the grapes at several Michigan grape-processing plants were observed.

A study of some of the physical properties of Concord grapes was made. This study included damage caused by dropping both bunches and single grapes onto hard surfaces and onto other grapes from different heights; subjecting the fruit to varying pressures; and simulating settling and crushing tests under those conditions which occur during transit from vineyard to processing plants. The purpose of this phase of the work was to determine facts that might prove useful in developing new handling methods.

During the 1959 season some mechanical harvesting studies were conducted. In harvesting experimental plots of grapes, the equipment developed for harvesting blueberries [4/] was used. Time, recovery, and quality data were taken.

Several chemical looseners were tried in an effort to facilitate separation and to minimize splitting the grapes. This phase of the work was done under the direction of Dr. Paul Larsen, Department of Horticulture, Michigan State University.

Several experimental handling methods were also tried. These included the palletized handling of 24,600 pounds of grapes in beer lugs, and the bulk box handling of an additional 15,000 pounds. A tractor fork lift was used in the vineyard to handle both unit loads and bulk boxes. The 30 (54" x 47" x 19") bulk boxes used were constructed according to the authors' specifications and given to the cooperating processor. A straddle truck was used in moving the bulk boxes from the vineyard to the processing plant.

RESULTS

Present Harvesting Methods Evaluated

In the conventional method of harvesting, the bunches of grapes are clipped (about 1 percent are snapped) from the vines and placed in lug boxes or "Welch" trays that have been previously distributed in the rows. Pickers usually work on the west side of rows that run north and south and on the north side of rows that run east and west. They work in this way because on these sides the foilage is less dense and the grapes easier to see. The workers are usually paid piecework rates

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4/ S. L. Hedden, H. P. Gaston, and J. H. Levin. (1959) Harvesting Blueberries Mechanically. Mich. Agr. Expt. Sta. Quat. Bul. Vol. 42, No. 2.

of 25 cents per lug or 20 cents per tray. The average adult picker earns from $1.25 to $1.50 an hour. Most beer lugs used in handling grapes have a capacity of from 38 to 40 pounds. The trays hold about 28 to 30 pounds.

PICKING STANDS. Usually the lugs and trays used in picking grapes are placed on the ground while they are being filled. If the bunches are laid in the containers, the picker has to stoop. If the bunches are dropped, the grapes tend to shatter and split. Some growers provide "picking stands," which hold the picking containers at about waist height. Some stands are simple, inexpensive wood frames which must be picked up when they are moved. Other stands are made like a wheelbarrow and can be wheeled down the row. Observations indicated that the use of these aids, which cost from one to several dollars, make the work easier and help to maintain quality.

OVER-FILLING. In an effort to reduce picking costs, most growers insist that their pickers "over-fill" the containers. The overfilling results in crushed grapes when the lugs are stacked (fig. 1). Some

Figure 1. Transferring filled used beer lugs from trailer to truck by hand is hard work. When over-filled lugs are stacked, the grapes are crushed and considerable damage is done.

producers justify this practice by saying that the fruit settles before the containers are stacked. However, the studies showed that overfilling leads to crushing, splitting, and fermentation of the grapes. (See section on Settling Tests.)

The study on harvesting methods led to the conclusion that conventional techniques could be materially improved.

Present Handling Methods Evaluated

FIELD HANDLING OF EMPTY CRATES. The 1-, 2-, 3-, and 4-row method of distributing empty crates are all in common use. The study indicated that the 3-row method is the most efficient. When this system is used, a load of empties is moved down every third "middle." Lugs are set off in the rows on each side and tossed over one row. Tossing the containers causes some breakage but this disadvantage is offset by reductions in labor.

FIELD HANDLING OF FILLED CRATES. The 1-row straddle, 1-row side, 2-, 3-, and 4-row systems of collection are in use. In all systems, except the 1-row straddle, the grapes are placed under the vines where they are partly shaded. Sometimes they are overlooked by the pickup crew. When the straddle method is used, high-clearance equipment is necessary and the work must be done quickly, otherwise the fruit is exposed to the sun until the pickup is made. They study indicated that the 2-row method is usually preferable. When this system is used a trailer is moved down alternate middles and the filled boxes are picked up from the rows on either side. This means that the boxes from one of these rows must be pushed into it or through it by the picker who worked from the other side.

In the 3- or 4-row method the filled boxes must be carried across the middles and pushed through. Most women and children have difficulty in carrying the filled boxes for even short distances.

DELIVERING LUGS TO PROCESSING PLANT. About 40 percent of the grapes produced in Michigan are moved from vineyard to processing plant by "custom truckers" who charge from 4 to 6 dollars per ton, depending on the amount of fruit and the mileage involved. Most grape growers whose operations are too small to warrant the purchase of a truck use the custom truckers. Many of these custom truckers use obsolete equipment and render relatively poor service. Better methods and equipment (straddle trucks) would increase the efficiency of the trucking operation and lower the costs.

Many growers hold about one day's pick under the vines or in a stockpile in order to have grapes on hand for delivery on a rainy day. In either case the fruit deteriorates during the holding period. Losses in weight averaged two percent per day and ran as high as four percent per day. On a seasonal basis, this loss is significant. A grower, for example, who produces 50 tons of grapes and holds them for 24 hours before delivery to the plant, loses a ton of grapes having a value of approximately $100. If weather conditions are unfavorable or the fruit is held over at the plant before it is unloaded, the losses are considerably greater.

Indirect losses due to deterioration of the grapes are probably more significant than most growers realize. Poor quality lowers juice yield and increases the cost of processing. The resulting losses are, in the end, borne by the grower.

PLANT HANDLING. In the conventional method of handling, the filled boxes are moved directly from the incoming trucks and trailers to the processing line. Most plants run continuously 24 hours a day. In order to avoid the possibility of running out of grapes the loads are scheduled to arrive before they are actually needed. This usually means that growers must wait for their trucks to be unloaded even when deliveries arrive on schedule. When breakdowns occur in the processing line and schedules are disrupted, trucks have to stand in line for many hours. After arrival at the plant the growers usually remain with the trucks from two to as much as 24 hours (fig. 2). At some plants the drivers are required to stay with their trucks until they are unloaded.

Figure 2. Grapes deteriorate rapidly between harvesting and processing. The losses caused by waiting in line--for as long as 24 hours--are considerable. When this picture was taken, 27 trucks were waiting to be unloaded.

Schedules call for deliveries night and day throughout the harvest season. This means that a driver may have to get up at 3:30 or 4:00 a.m., and if he is delayed, he may not get home until noon. This system has obvious disadvantages.

At some plants arrangements can be made to have the trucks moved and unloaded by plant personnel. Grapes are weighed just prior to unloading and not upon arrival at the plant. This means that the grower is penalized by the shrinkage which occurs during the waiting period. Under unfavorable conditions -- when the humidity is low, the grapes overripe, and the containers overfilled -- the losses are substantial.

CONTAINERS. At present most Michigan-grown grapes are handled in either trays or used beer lugs made from wood, which were purchased several years ago at a small fraction of their original cost. There are about 400,000 of these containers in the hands of Michigan growers and processors. Approximately 10 percent of these lugs must be repaired annually and about that many more are so badly damaged during the season that repairs are impractical (fig. 3). Because paper-board cartons are

Figure 3. Damaged used beer lugs being sorted. The cost of repair, replacement, and storage of these boxes is one of the major problems facing the grape industry.

now used for handling bottled and canned beer, used beer lugs are no longer available. Most lugs now in the hands of growers are several years old and many are in bad condition. Maintenance costs are high and breakage is considerable. At present prices, replacement costs run from 75 cents to $1.00. Processors say that they cannot afford to supply new containers and continue to pay current prices for grapes.

QUALITY. Insects, mold, and fermentation have adverse effects on quality. Many conventional handling practices, such as overfilling, accelerate quality deterioration. Methods and equipment that will help to maintain on-the-vine quality will benefit all concerned.

Physical Property Studies

Very little information concerning the physical properties of Concord grapes is available. The dropping and crushing studies reported here were made in an effort to obtain information that would make it possible to develop better handling methods and equipment.

DROP TESTS. Results of these tests are summarized in Table 1. This work indicates that bunches of grapes should not be dropped more than 6 inches. It was found, however, that single grapes could be dropped as much as 18 inches without causing significant damage.

Table 1. Average percent of Concord grapes split by dropping on a flat wood surface from varying heights. 1/

Height of drop	Single fruits	Bunches
Inches	Percent Split	Percent Split
6	0	0
12	0	35
18	0	45
24	10	50

1/ Based on dropping 40 pounds of grapes.

PRESSURE AND PILING TESTS. In these trials both bunch and shelled [5/] grapes were subjected to various pressures and piled to depths of from 6 to 24 inches. It was found that bunch grapes could be piled to a depth of 18 inches without seriously damaging the fruit. The depth to which shelled grapes could be piled without damage was somewhat less.

SETTLING TESTS. Freshly picked bunch grapes were piled in a lug box to a depth of 10 inches and allowed to stand for 48 hours. At the end of this time measurements showed the amount of settling that had occurred was insignificant.

Other lots of bunch grapes were piled to a depth of 24 inches and then hauled approximately 7 miles in a pickup truck. Measurements showed that on the average the grapes had settled approximately 2-1/2 inches, or about 10 percent.

The results of further studies of the damage which occurs when grapes settle during transport appears in table 2.

Table 2. Average percent of bunch grapes split during transport [1/]

Depth at which grapes were piled	Split grapes
Inches	Percent
12	1
14	4
18	6-8
21	10-12
24	15-20 [2/]

1/ Based on three trips in which grapes were transported, in column of 24 inches deep and 1 foot square, 7.1 miles in a pickup truck.

2/ Some free juice.

These studies indicate that bunches of Concord grapes, piled to a depth of 18 inches, can be handled without appreciable damage. This information was used in designing the bulk boxes used in the handling trials described below.

5/ Shelled grapes are those that have dropped off the bunch grapes.

OTHER PROPERTIES. It was found that the fruit accounts for 97 percent of the weight of bunched grapes, while stems make up only 3 percent. Another check showed that shelled grapes occupy only about 75 percent of the volume taken up by bunch grapes.

MECHANICAL HARVESTING

Two 14-vine rows of Concord grapes were harvested with the equipment developed for harvesting blueberries (fig. 4). The mechanical

Figure 4. The equipment developed for harvesting blueberries proved to be an effective means of separating grapes quickly and easily.

vibrators used to separate the fruit moved metal fingers through an amplitude of one-fourth inch at 800 cycles per minute. When the vibrator was held against fruit-bearing canes near the points at which the bunches were attached, the grapes separated from the stems quickly and easily. The hand-held vibrators were activated by a small gasoline-powered electric generator. The separated grapes were caught in lightweight canvas-covered collecting units that were pushed under the vines.

In some earlier work done in an effort to find an effective grape defoliant, Dr. Paul Larsen observed that one of the materials used tended to loosen the grapes and also made it possible to shake them off without a significant amount of cracking. While this particular material had undesirable side effects which eliminated it from serious consideration, the experiment did indicate that a practical loosener might be

found. In an effort to discover such a material, several different sprays were used in connection with the harvesting trials conducted in 1959. While none of the materials used that year had the desired effect, plans are being made to continue the search.

The results of the harvesting trials are presented in table 3. They show, among other things, that the vibrator separates all of the grapes; and that the fruit was harvested at the rate of 318 pounds per man-hour, which is about twice the rate at which they are normally picked by hand. However, between 45 and 50 percent of the grapes were cracked by the harvesting process. Studies showed that the cracking occurred during the separation process and was not caused when the grapes fell into the collecting unit.

Table 3. Studies of mechanical grape harvesting [1/], and chemical defoliants (Sept. 1959 Sodus Exp. Station)

Defoliant No. [2/]	No. of vines	Pounds harvested	Pounds per vine	Pounds per minute	Time in minutes	Minutes per vine
1	6	88.0	14.7	4.5	19.7	3.6
2	3	42.5	14.2	4.7	9.1	3.0
3	6	107.0	19.5	5.5	19.6	3.6
4	5	85.0	17.0	5.2	16.4	3.3
5	3	54.0	18.0	8.0	6.7	2.2
Check [3/]	2.5	59.5	23.8	5.6	10.7	4.3
Totals	25.0	436.0	17.4	5.3	82.2	3.3

1/ Equipment used -- machines developed for harvesting blueberries.

2/ Treatments were with commercial chemical defoilants.

3/ The grapes on the check vines were not as mature as those produced by treated vines.

Pallet Handling

Two methods of pallet handling were tried. In one method a low narrow trailer containing the pallets was pulled down alternate middles. The filled boxes were picked up by hand and stacked on the pallets. When a load had been accumulated the trailer was moved to a loading area near the vineyard where the palletized lugs of grapes were handled with fork-lift equipment as unit loads. They were then transferred directly to road trucks or stockpiled until a truck was available.

In the second method a tractor fork lift carrying one pallet was driven down alternate middles. The filled boxes were stacked on this pallet. When a unit load had been accumulated, it was moved to the end of the row and loaded onto a truck or set on the ground (fig. 5).

Figure 5. Tractor lift equipment being used to handle a 40-lug unit load of grapes.

Tables 4 and 5 show the time required to perform the various operations involved in each of the handling methods tried. When the work was done by hand, the filled boxes were handled at the rate of about 40 per man-hour. Pallet handling increased the rate to 59 boxes per man-hour when trailers were used. When the pallets were moved down the rows on a tractor lift, the rate was 79 boxes per man-hour. The figures indicate that one fork-lift unit can handle up to 40 tons of grapes in an 8-hour day. The results show that growers who have 30 or more acres of grapes are justified in providing themselves with a lift equipment. Producers who grow less than 30 acres may elect to use lift equipment not because it increases profits but because it makes the work easier.

Table 4. Pallet handling, using trailers

Operation	Time per 80 box cycle (two-pallets)
	minutes
Travel with empty trailer 1/	2.71
Loading boxes on pallets on trailer 2/	13.20
Travel with load to dock area 3/	1.71
Transferring loaded pallets--trailer to truck 4/	2.84
Total	20.46 minutes 5/

1/ Average distance 1200 feet at 5 m.p.h. (loading area to filled boxes in the vineyard).
2/ Pallets held 40 boxes each - two pallets were used on a trailer. Crew consisted of four men - one on tractor, one on trailer, and two on ground.
3/ Average distance 300 feet at 2 m.p.h. - trailer held 80 boxes.
4/ Equipment consisted of a farm tractor equipped with fork-lift attachment on rear.
5/ 80 boxes - four men, 59 boxes per man-hour.

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Table 5. Pallet handling, using tractor fork-lift

Operation	Time per 40 box cycle
	minutes
Pickup empty pallet at loading area 1/	0.37
Travel with empty pallet 2/	2.71
To load full boxes on pallet 3/	5.56
Travel to dock area with load 4/	1.71
To stockpile full pallets	0.25
Total	10.60 minutes 5/

1/ Tractor equipped with fork-lift attachment on rear only.
2/ Average distance 1200 feet at speed of 5 m.p.h.
3/ Forty boxes placed on each pallet. Crew consisted of three men (one on tractor and two on ground).
4/ Average distance 300 feet at speed of 2 m.p.h.
5/ 40 boxes - three men, 75 boxes per man-hour.

Pallet handling not only increases the efficiency of on-the-farm handling but also reduces the number of men required, reduces congestion, and speeds up at-the-plant handling.

Bulk Box Handling

In the bulk-box handling trials, a bulk box carried by a tractor fork lift was backed down a middle. The grapes were picked into lugs and then transferred from the field containers to the bulk box as the tractor moved along (fig. 6). When it had been filled, the bulk box was moved to a nearby loading area and placed on two 4" x 4" bolsters.

Figure 6. Grapes being transferred from the lug boxes into which they were picked to a bulk box being moved between rows by tractor fork lift.

When 15 boxes were in place they were picked up by the straddle truck and moved to the plant (fig. 7), where they were emptied into the wash tank by means of a chain hoist tipping mechanism.

Grapes piled to a depth of 15 to 18 inches could be handled in bulk boxes without serious damage. The quality of the bulk-handled grapes was equal or superior to comparable lots that were handled in lugs.

Figure 7. Straddle truck carrying 15 bulk boxes filled with grapes being moved from vineyard to processing plant.

Time studies showed that the bulk handling method enabled workers to handle grapes at the rate of about 60 lugs per man-hour as compared to 40 lugs when the conventional method is used. The trials also indicated that straddle truck handling has many potential advantages. It should reduce transportation costs and make it possible to improve scheduling, thereby eliminating congestion and delays at the plant.

Because bunch grapes tend to nest and "lock" together they do not flow down slopes of less than 70 to 80 degrees. Because of this characteristic, some difficulties were encountered in emptying the bulk boxes used in the trials. This difficulty, however, probably can be eliminated by the use of a box that has a hinged door at one end.

The bulk box trials were so promising that the cooperating processor asked that the work be continued on an expanded basis during the next season.

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6/ Mention of company of trade names is for information and convenience only and does not imply endorsement by the U. S. Department of Agriculture over firms or products not mentioned.